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PRACTICAL DESIGN ASPECTS FOR INLAND NAVIGATION VESSELS TO OPERATE ON THE DANUBE RIVER BETWEEN THE PORTS OF PASSAU TO SULINA (KM 2233 TO KM 0)

Iliescu Robert Ionuț
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati,
Str. Domnească nr. 47, 800008, Romania
E-mail: ri164@student.ugal.ro

Adrian Presură
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati,
47 Domneasca Street, 800008, Romania,
E-mail: adrian.presura@ugal.ro

ABSTRACT

The article aims to line up the main design aspects that are to be accounted in the process of designing an inland vessel for navigating on the Danube River from Passau Port (at Km 2233) to Sulina (at Km 0). The design process itself is comprehensive and must comply with many regulations and Danube River environmental parameters, therefore, this article will offer an organized perspective about what must be considered depending on the type of vessel and specific navigation sector.

Keywords: design aspects, inland vessel, Danube River, rules and regulations.

1. INTRODUCTION

The purpose of this article is to present key aspects of the Danube River that will influence the design of the vessel in many ways such as draught, air draught, width and length of the vessel or the convoy, power of the engine, the amount of goods or passengers transported, the fuel, water and sewage storage or the accommodation compartments for the crew/passengers of the vessel.

The article will describe 3 main sectors as the Danube River covers a vast number of reliefs in its 2233km long journey. Each section will contain general, but crucial information about the part of the river that is taken into consideration such as depth of the waterway, lock chambers dimensions water flow speeds. Also, there will be mentions about regulations on the Danube, in accordance with Local and International Authorities Rules.

2. RULES AND REGULATIONS THAT MUST BE CONSIDERED WHEN DESIGNING A SHIP

When designing a ship, we must acknowledge that the designer company follows a set of rules based on the type and purpose of the vessel, and some regulations depending on the area which the vessel will operate in. In this case, which is designing an inland vessel, the designer must consider the specific set of rules made according to the environment and situations found on a

river or other inland navigable affluent. For this matter the designer will have to comply with IACS Classification Society Rules, for example Bureau Veritas and Det Norske Veritas [1], and needs also to comply with the standards imposed by ES-TRIN [2] when the vessel will be built in European Union Countries.

At the same time, depending on the vessel's flag, based on the country where the vessel will be registered, the designer must consider the local regulations imposed by the Riparian states. In the case of the Danube River, we are taking into consideration the regulations imposed by Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Ukraine and Republic of Moldova [3]. The designer should also look for additional information on studies about specific aspects of the Danube River such as depths and widths of the waterway [4].

For a safe operation it is very important that the designer complies with the rules, standards and regulations mentioned in this article when designing a vessel to operate on the Danube River.

3. SECTOR I: PASSAU PORT – BRĂILA PORT (KM 2233 – KM 170)

This section is by far the biggest one compared to the other two, according to its lenght.

a. Waterways and critical locations on Danube River

Accordong to the Manual on Danube Navigation [3], based on Convention Regarding the Regime of Navigation on the Danube, the minimum draught loaded of vessels on an international waterway is 2.5m at Low Navigable Water Level (LNWL).

This minimum water depth limit is to be mantained by the riparian states for good navigation conditions.

Altough this rule exists, there are regions where the river depth is not properly mantained especialy in the late summer and early autumn (August to November) due to drought. According to Fairway Rehabilitation and Maintenance Master Plan for the Danube and its navigable tributaries (FRMMP) [6], the main critical locations on Danube are shown in the following table.

Table 1. Critical location along the Danube

Critical locations on Danube		
Riparian state	Location	rkm from-to
Austria	Wachau	-
	East of Vienna	-
Slovakia	part I. (rkm 1880 - 1863)	-
		-
	part II. (rkm 1810 - 1785)	-
		-
	part III. (rkm 1765 - 1710) including Nyergesujfalu	-
		-
		-
Hungary	Nyergesujfalu	-
	Kisapostag	-
	God	-
	Domos also	-
	Budafok	-
Croatia	Apatin	-
Serbia	Futog	-
Romania	Bechet	-
	Corabia	-
	Turcescu	-
	Cochirleni	-
	Seimeni	-

	Prut	-
	Tulcea	-
Bulgaria	Somovit	610-607
	Sredniak island Palets island	591-584
	Belene island Milka island Kondur island	569-561
	Vardim island	548-540
	Yantra River Giska island	539-530
	Batin island	525-520
	Gostin island	476-472
	Mishka island	463-460
	Barshlian island	458-455
	Radetski island	441-435
	Kosui island Dunavets island	426-420
	Malak Preslavets island	414-410
	Popina island	408-399
	Vetren island	395-390
	Chajka island	386-382

The bathymetric measurements made in the past reveals that the water level on the Romanian sector can reach 1m below the minimum 2.5m in the drought season and represents a critical aspect for river cargo and passenger navigation.

It is worth mentioning that the flow speed of the Danube's waters has significant influence on the critical depth sectors, as the water flow decreases, the risk of sediments deposition increases. For example, in Bratislava the approximatively water speed is 8-10km/h and on the Romanian sector about 1.5-4.5 km/h.

Table 2. Lock chamber locations and dimensions

Location (State)	River-km	Dimensions	
		Length (m)	Length (m)
Kachlet (DE)	2230.60	226.50	24.00
Jochenstein (DE/AT)	2203.20	227.00	24.00
Aschach (AT)	2162.80	230.00	24.00
Ottensheim-Willhering (AT)	2147.04	230.00	24.00
Abwinden-Asten (AT)	2119.75	230.00	24.00
Wallsee-Mitterkirchen (AT)	2095.74	230.00	24.00
Ybbs-Persenbeug (AT)	2060.29	230.00	24.00
Melk (AT)	2038.10	230.00	24.00
Altenworth (AT)	1980.53	230.00	24.00
Greifenstein (AT)	1949.37	230.00	24.00
Freudenau (AT)	1921.20	275.00	24.00
Gabcikovo (SK)	1819.42	275.00	34.00
Dredap / Portile de Fier I (RO/RS)	942.90	310.00	34.00
Dredap / Portile de Fier II (RO/RS)	863.70 862.85	310.00	34.00

b. Limitations for vessel dimensions on Sector I

The limits of the length, width and draught of the vessels are related to the fairway dimensions in general, and to the lock chambers found on the Danube River.

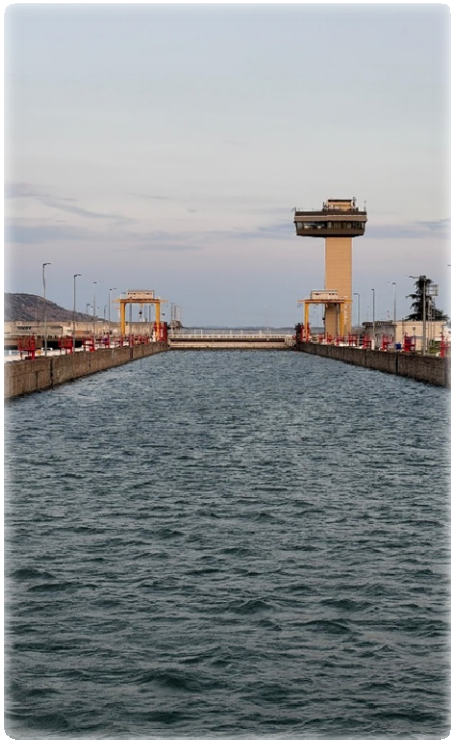

Figure 1 Photo from Iron Gates I

c. Port and facilities along Sector I of the Danube

Along the Danube River, from Passau to Brăila, there can be found 55 ports. The type of port is different from one to another and so is the dimension of the port and the facilities that it offers. These stations offer the possibility to dispose of liquid waste such as bilge water and waste water and, in some cases the stations can collect solid waste (residual waste, solid oily materials). Mobile collection vessels are available along the river for extraction of bilge water and other types of waste such as waste oils.

It is of maximum importance to mention that anywhere on the Danube River it is prohibited to discharge any type of waste into the river water. Only residual treated water can be discharged into the waterway; in consequence the designer must consider sufficient waste liquids storage capacity or treatment plants onboard the vessel.

When it comes to fresh water and fuel, it can be said that the availability of bunkering possibilities is more flexible, as many of the ports offer potable water supply and fuel can be filled in from floating or road facilities.

Figure 1. Photo of a river port quay

I.

II. 4. SECTOR II: MARITIME DANUBE (rkm 170/ rNm 92 – rkm 0/ rNm 0)

This sector is subject to river and maritime vessels traffic, as it makes the conection between Danube and the Black sea. Beacause of that it has special rules that regulate the traffic on the fairway.

The article will mention essential rules for the desinger, so for more information about restrictions and regulations on this Romanian sector of the Danube, the reader can check RND [5].

According to:

- **RND, Part II, Chapter 1, Article. 1.02, Parag. 2**

All maritime ships are obliged to have lights and signals as requested in the International Regulations for Preventing Collisions at Sea [8].

Type of the vessel	Upstr.	Downstr.
Small vessels	8 Nd	9 Nd
Tugboat or convoy	8 Nd	9 Nd
Passenger ships, Rescue vessels, Military ships	9 Nd	10Nd
Maritime ships <=4000 tDW	7 Nd	9 Nd
4000 tDW < M.S<12.000 tDW	6 Nd	8 Nd
12.000tDW<M.S<25.000tDW	5 Nd	7 Nd

- **RND, Part II, Chapter 2, Art. 2.03**

Ships with a transversal incline of more than 4° are not allowed to navigate on the maritime sector of the Lower Danube.

- **RND, Part II, Chapter 3, Art. 3.05, Parag. 1**

On the maritime sector of the Lower Danube from Brăila to Sulina harbor, in normal conditions, all maritime ships and inland-maritime vessels will navigate with a freshwater draught of maximum 7.01 meters (23 feet).

- **RND, Part II, Chapter 3, Art. 3.05, Parag. 2**

In this sector navigation is allowed, in normal conditions, to ships with maximum length of 180m and maximum width of 40m.

- **RND, Part II, Chapter 3.1, Art. 3.1.01**

Sailing ships with a tonnage that exceeds 50 tons are not allowed to navigate on Sulina Canal.

- **RND, Part II, Chapter 3.1, Art. 3.1.02**

In no restriction sectors, the navigation speed on the canal is decided by mutual agreement between the pilot and the captain of the ship and cannot exceed the limits established below for normal hydrometeorology conditions.

The rules above represent special rules for the maritime sector of the Danube River which complement the basic rules for navigation on the Danube. The rules must be checked before the start of navigation on the river.

5. SECTOR III: DANUBE-BLACK SEA CANAL (Rkm 64+410/ 0+000)

The Danube-Black Sea Canal is an artificial 64.41km long canal that connects the Danube River with the Black Sea. At Poarta Albă the canal splits into two canals, the main one is called Danube-Black Sea Canal and goes from Cernavodă to the maritime Port of Constanța and the secondary one from Poarta Albă which is located on the main canal, goes to Midia-Năvodari, both canals ending at the Black Sea ultimately.

The water flow speed on the two canals is maximum 5km/h.

In the following part of the chapter, the article will present some facts and rules according to the canal administrator [6], about the canals that will help the designer to understand what to keep in mind when desinging the ship.

- **RN-CDMN-CPAMN, Chapter 2 Art.8, Parag. 4**

Sailing ships and rafts are not allowed on the navigable canals.

- **RN-CDMN-CPAMN, Chapter 2, Art.9, Parag. 1**

To navigate safely on the canals for the convoys pushed or towed there must be a tugboat that has sufficient power to assure a minimum of 6.7tm/Hp on the Danube-Black Sea Canal and 6tm/Hp on Poarta Albă-Midia-Năvodari Canal.

- **RN-CDMN-CPAMN, Chapter 6, Art.49, Parag.2**

It is prohibited to discharge ballast, waste water, bilge water or to clean the liquid tanks on board when navigating through the canals.

a. Danube-Black Sea Canal

The canal presents two lock chambers. The following table shows the dimensions of the lock chambers.

Lock Chamber	Dimensions			Location (rkm)
	Length (m)	Length (m)	Length (m)	
Cernavodă	310	25	min4.5 max.12	60+305 (4+105)
Agigea	310	25	min7.00 max.8.5	1+912 (62+498)

- **RN-CDMN-CPAMN, Chapter 2, Art. 7, Parag. 1**

According to the canal administrator only the convoys and vessels that respect the following dimensions are allowed to pass through the canal:

Type	Length (m)	Width (m)	Draught (m)	Air draught (m)
Convoy	296	23.5	5.5	16.5
Inland vessel	138.3	16.8	5.5	16.5
Maritime vessel				

- **RN-CDMN-CPAMN, Chapter. 6, Art.38, Parag. 1**

When navigating on Danube-Black Sea Canal the vessel must not have a speed lower than 6.5km/h and not higher than 12km/h.

b. Poarta Albă-Midia-Năvodari Canal

The canal presents two lock chambers. The following table shows the dimensions of the lock chambers.

Lock Chamber	Dimensions			Location (rkm)
	Length (m)	Length (m)	Length (m)	
Ovidiu	145	12.5	min4.5 max.12	60+305 (4+105)
Năvodari	145	12.5	min7.00 max.8.5	1+912 (62+498)

- **RN-CDMN-CPAMN, Chapter 2, Art. 7, Parag. 1**

According to the canal administrator only the convoys and vessels that respect the following dimensions are allowed to pass through the canal**.**

Type	Length (m)	Width (m)	Draught (m)	Air draught (m)
Convoy	120	11.5	3.8	12.5
Inland vessel	110	11.5	3.8	12.5
Maritime vessel				

- **RN-CDMN-CPAMN, Chapter. 6, Art.38, Parag. 1**

When navigating on Poarta Albă-Midia-Năvodari Canal the vessel must not have a speed lower than 6.5km/h and not higher than 10km/h.

6. LIQUID RESERVES ONBOARD INLAND VESSELS

When dimensioning the liquid tanks the designer must find the optimal solution in case of fuel reserves for example, as mentioned above in Chapter III, letter C, the availability of refueling is to be considered and the stops along the Danube River must be calculated before departure. The same situation is with freshwater too.

The freshwater tank must be sufficient to provide a minimum of 150L/person on board/day, according to ES-TRIN [2].

The tanks for collecting the waste water must be dimensioned so that the waste is disposed only in authorized zones and not in the waterway. Additional measures like including a sewage system onboard the vessel are to be considered for large passenger vessels.

7. EMITTED GASES

All propulsion engines and auxiliary engines onboard a vessel with a power > 19 kW must comply with the pollution norm Stage V that refers to the pollution emissions with gaseous elements, according to European Regulation 2016/1628 [9].

Since the introduction of the first pollution standard regarding exhaust gases from internal combustion engines "Stage I" in 1998 and until the latest pollution standard currently in force "Stage V", the permissible limits of these emissions have been drastically reduced, thus

- HC+NOx (g/kWh) - 94% reduction
- PM (g/kWh) - 97% reduction

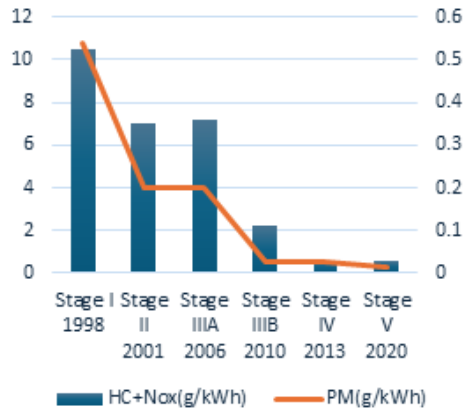

Figure 3 Gaseous emissions reduction

8. MINIMUM SAFETY CREW

The minimum safety crew term refers to the minimum number of crew members a vessel crew must have to navigate on the Danube River.

The number of crew members differs from one vessel to another and much more from a vessel that has an automation level higher than the other. More than that it depends on what mode of operation is chosen for the vessel. There are 3 modes of operation:

- **A1:** Daytime navigation – maximum 14h within a period of 24h.
- **A2**: Semi-continuous navigation – maximum 18h within a period of 24h.
- **B:** Continuous navigation for 24h and more.

The designer of the vessel should keep in mind that with the increasing crew member numbers it means increasing the number of cabins and assuring comfort on board the vessel for more people. This balance of capacity for assuring comfort for several crew members and the ability to travel a shorter or longer period is to be established by the purpose of the vessel.

For furthermore information about the exact number of crew members according to the vessel type, the reader can look at Ordin 434/2009 [7].

CONCLUSIONS

This article highlighted practical aspects that can help the naval architects to understand the importance of the regulations and environment and dimensional limitations of the vessels built for the Danube River, that can help them in designing an inland vessel that can operate at optimal performance according to the river particularities and in accordance with the legal applicable requirements.

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